

The possible functional role of periostracal processes in *Japonia saetigera* (van Benthem Jutting, 1958) (Caenogastropoda: Cyclophoridae) based on SEM micrograph analysis and numerical calculations

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Abstract: A possible explanation for the functional importance of shell appendages in *Japonia saetigera* (van Benthem Jutting, 1958), an endemic New Guinean terrestrial cyclophorid gastropod, is given based on a morphology and calculation-based model and scanning electron microscopy. Results demonstrate that the periostracal processes increase the perimeter length of the ultimate whorl by nearly 42%, the net dorsal shell surface area - by about 20%, and the shell volume by only around 1% in the studied specimen. Possible adaptive importance of periostracal processes in *J. saetigera* is hypothesised and discussed. New distributional record for *J. saetigera* is presented.

Key words: Shell morphology, adaptations, adhesive properties, floating, air bubbles, ecology, Papuan Region.

Introduction

In molluscs, the calcium carbonate (calcareous) shell is covered externally by a thin proteinic layer composed of conchiolin, the periostracum, which is in part mineralized and, thus, involved in shell formation (de Paula & Silveira 2009). The periostracum of some pulmonate species is of taxonomic interest since microscopical structures often derive from it. Periostracal setae or hairs are the most common and extensively studied type of such structures, but some species develop extreme clava-, spoon- or feather-like periostracal structures (cf. Figs 1, 25–26). Allgaier (2011) described such morphology and Suvorov (1999) and Pfenninger et al. (2005) discussed the functional role and evolutionary importance of periostracal setae in selected terrestrial European Helicidae, Helicodontidae and Hygromiidae taxa. Both studies found that the possession of periostracal setae

facilitates the adherence of the shells to wet surfaces and highlighted correlation of setation loss with a shift from humid to dry habitats in terrestrial molluscs.

Japonia (*Mylicotrochus*) *saetigera* (van Benthem Jutting, 1958) (Figs 1–3) is terrestrial cyclophorid (Cyclophoridae Gray, 1847) species endemic to Misool Island (Raja Ampat Islands) off the coast of western New Guinea. Prior to this study this species was known only from the type series collected in the northern part of Misool and is peculiar among hitherto known Papuan terrestrial molluscs due to specific spoon-like “bristles” which are regularly, moderately widely spaced along the flat peripheral carina of the teleoconch (van Benthem Jutting 1958). The morphology and function of these “bristles” (referred to further in the text as periostracal processes) have not been previously studied in detail. Acquiring additional specimens of this species made our studies



on the morphology of periostracal processes in *Japonia saetigera* possible, the results of which are presented and discussed further.

The primary aim of the present paper is to initiate a discussion on the possible adaptive role of non-hair-like periostracal processes in terrestrial molluscs living under humid conditions, as well as an attempt to estimate contribution of periostracal processes to the net surface area and volume of the studied molluscan shell. The present study does not pretend to be comprehensive and is to be considered as an initial part of a larger scale study.

Material and methods

The first author identified the specimens used for the present research. Studied specimens were fixed in 99% ethanol but all were empty shells with no body. The holotype is also only a dry shell and is stored dry. Only one of the four studied specimens (inclusive of the holotype) has most of the periostracal processes present, therefore we based our research and calculations on this best-preserved specimen only. A Leica S6D stereomicroscope was used for species identification. For micrograph imaging a Scanning electron microscope (SEM) was used facilitated by the Faculty of Biology, University of Latvia. To prepare specimens for imaging, shells were ultrasonically cleaned in distilled water for 1-2 minutes, washed through a graded alcohol series up to 99%, air-dried and then placed dorsally onto conductive tape on aluminium stubs. Selected samples (Figs 12–22) were coated with 20 nm Au in an ion coater Eiko IB-3 before observations were made. All shells were imaged using a Hitachi TM-3000 (Hitachi High Technologies ®) SEM following methods as described by Geiger *et al.* (2007).

Data from labels are reproduced verbatim, without additions. Labels (if there are multiple labels on a specimen) are separated by a slash. Authors' comments are placed in square brackets.

The Papuan Region as considered here is a zoogeographical term in the sense of Gressitt (1982), Beehler *et al.* (1986), Riedel (2002), and Telnov (2011).

The studied material is stored at the following collections:

KGC – Collection Kristine Greķe, Rīga, Latvia;
NME – Naturkundemuseum Erfurt, Germany;
NMNL – Naturalis Biodiversity Center, Leiden, the Netherlands.

Measurements and calculations

Measurements of periostracal projections taken from SEM micrographs. Measurements of shell taken with a stereomicroscope (see above) using a reticule.

The model

The surface area and volume of the shell (not including the periostracal processes) is modelled separately from the surface area and volume of the periostracal projections on it, so that their contribution can be compared to the overall value. As such, the periostracal processes of the shell and the shell itself are treated separately, and both can be modelled as solids of revolution (for description of this model see Harris & Stocker (1998) and Weisstein (2020a)). The perimeter length of a single periostracal process was found by calculating the arc length of the generatrix function of the said surface of revolution (Weisstein 2020b) and multiplying it by 2 since the generatrix is rotated 360° and is thus mirrored along the axis of symmetry. The areas were modelled as surfaces of revolution (for description of this model see Weisstein (2020c)). These models are based on several assumptions, which were observed to hold true for both the periostracal projections and the shell (together and separately called the object) on magnification of up to 200x:

The object is radially symmetrical along its axis of symmetry;

The surface of the object is smooth and continuous on every freely selected segment;

The surface of the object has a negligible thickness.

Since these conditions hold only for a certain scale (for instance, surface of shell whorls is rarely entirely smooth under magnification since axial ribbing patterns are present and periostracal projections are not entirely smooth under high magnification) and are not “truly” satisfied, the model is expected to produce minor errors, dependent on the extent to which these conditions are not met.

The formulae used

The formulae for double arc length, the surface area and volume of a solid of revolution are:



$$P(h) = 2 \int_a^b \sqrt{1 + \left(\frac{dr}{dh}\right)^2} dh \quad (1)$$

$$S(h) = 2\pi \int_a^b r(h) \sqrt{1 + \left(\frac{dr}{dh}\right)^2} dh \quad (2)$$

and

$$V(h) = \pi \int_a^b r^2(h) dh \quad (3)$$

respectively, where r is the generatrix of the solid of revolution, h is the distance along the axis of symmetry (or, for case of mollusk shell, its dorso-ventral axis) and (a, b) are the boundaries of the freely selected region.

The uncertainties calculated in this work are results of propagating potential errors in measurements, and do not account for possible deviations from the model, uncertainty in regression, rounding errors or variations in statistical distributions.

The following software was used for the calculations: OriginPro data analysis tool v. 9.8, Wolfram Alpha (<https://www.wolframalpha.com>).

Results

Taxonomy and morphology

Japonia (Mylicotrochus) saetigera (van Benthem Jutting, 1958) (Figs 1–24)

Holotype NMNL: Holotype en Paratypen [handwritten] Zoölogisch Museum. Amsterdam. [printed] *Lagochilus* (*Mylicotrochus*) *saetigerum* v.B.Jutting Fakal, 0-75 m hoog Centraal Misool 7 Oct.1948 leg. M.A. Lieftinck [handwritten, the Latin name is underlined] / Holotype [printed] / holotype 3.58.010 1 dr ZOOLOGISCH MUSEUM AMSTERDAM ZMA Moll. 135638 Cyclophoridae 0767.0 *Lagochilus saetigerum* Van Benthem Jutting, 1958 INDONESIA Papua Misoöl, Fakal, 0-75 m 1948 10 07 sta. Leg.M.A. Lieftinck Ex coll. Original publication: Van Benthem Jutting, W.S.S., 1958 Non-marine Mollusca of the island of Misool. Nove Guinea, new ser., 9(2): 293-338 Autoref: Van Benthem Jutting, W.S.S., 1958e: 304-306, fig. 3 Add.publ. Notes: Current Scientific Name: *Lagochilus saetigerum* Van Benthem Jutting, 1958 Det. / Naturalis Biodiversity Center 40380 – Cyclophoridae *Lagochilus saetigerum* van Benthem Jutting, 1958 – HOLOTYPE Lieftinck, M.A., c. Indonesia, Papua, Misool, Pulau, Fakal; depth [sic! altitude] 0-75 m 7.x.1948 [printed].

Additional studied material, 3 specimens NME & KGC: INDONESIA E, Prov. Raja Ampat, distr. Misool Barat, Lilinta (Lelintah) vill. ~13.5 km NW, Gamta vill.

~11 km NWW, River Gam valley in the middle of course, 01°57'46"S, 130°10'54"E, 03.IV.2009, primary lowland rainforest, limestone creek [of the three specimens, one bears complete periostracal projections and two other lack them or only have fragmentary processes present].

Note: Assuming that “*saetigerum*” (as originally of van Benthem Jutting (1958)) is a Latinized Greek adjective and not a noun, we consider it appropriate to change the ending of the specific epithet to “*saetigera*” when combined with a feminine generic name *Japonia*.

Taxonomy: This taxon was originally described as *Lagochilus saetigerum* in the subgenus *Mylicotrochus* (van Benthem Jutting 1958). *Lagochilus* Fischer, 1885 and of later authors is an unjustified emendation of *Lagocheilus* Theobald in Blanford, 1864 and a junior homonym of *Lagochilus* Loew, 1860 (Diptera), now a subgenus of *Japonia* A. Gould, 1859 (Egorov 2009). *Mylicotrochus* P. Sarasin et F. Sarasin, 1899 was originally erected as a subgenus of *Lagochilus* for a single Sulawesi species *Japonia (M.) celebensis* on the basis of peculiarities of the radula (Sarasin & Sarasin 1899). However, the radula of *Japonia saetigera* was not described by van Benthem Jutting (1958) and remains unknown since no preserved anatomical material is available. Therefore, the original placement of *Japonia saetigera* in the subgenus *Mylicotrochus* by van Benthem Jutting (1958) was not fully justified. However, we do not intend to change the initial subgeneric placement at this point.

Morphology of periostracal processes: In *Japonia saetigera*, periostracal processes are absent on the protoconch but are present on older parts of the teleoconch (Figs 4–5) which follow the microscopically pitted protoconch (Fig. 5). On the teleoconch, every fifth or sixth radial growth line of the periostracum is accentuated with a lamellar periostracal extension (Figs 1, 4, 6), which is stronger-built than the surrounding, less prominent, radial periostracal growth lines. These stronger, lamellar growth lines each end in a conspicuous periostracal process (Figs 1 & 4). On the first 1-1½ teleoconch whorls, periostracal processes are shorter and clavate (e.g., like a finger or bowling pin) (Figs 4, 7–11), with a suture on ventral side (Figs 7, 10–11). On later whorls the clavae “open” along this suture and develop a conspicuous spoon-like shape, with the convex side facing upwards (Figs 1, 4, 12, 18). The external surface of each process (both clavate and spoon-shaped) has gentle irregular, transverse



concentric ridges (growth lines?) and somewhat lower, irregular, longitudinal interconnecting ridges between the concentric ones (Figs 7–8, 10, 12–16). Concentric ridges represented by different layers of periostracum partially overlap each other with the posterior margin of each layer (Figs 14–17). Clavate processes on the first teleoconch whorl are empty inside (filled with an air bubble). The underside of the spoon-shaped process (in fact – the inner side of the clavate process of the earlier whorls) is nearly smooth and glabrous, with a few irregularly spaced, gentle, circular to slightly ovoid pores (Figs 20 & 22) of approximate 0.5 to 1.5 µm in diameter (measured from one process, not statistically proven). Spoon-shaped periostracal processes of the last teleoconch whorls (the pen- and ultimate whorls of the shell) are about 3–4x as large as the smaller clavate processes of earlier whorls (Table 1). Both clavate and spoon-shaped processes are strongly attached to periostracum and hard to remove. In subfossil calcareous *J. saetigera* shells without periostracum there are no traces of peripheral processes or their points of articulation. Shells from living *J. saetigera* specimens do not become dirty from its microhabitat (a mixture of soil and litter). Length of periostracal processes: small (50–100 µm), mid-sized (100–300 µm), large (400–700 µm) (measured from one shell specimen only, not statistically proven).

Ecology: Occurs in wet leaf litter in primary lowland rainforest on limestone.

Distribution: Endemic to Misool Island, Raja Ampat Islands. The record provided in this paper is the first record of *J. saetigera* since the original description and the first locality in southern Misool.

Calculations for the periostracal processes

For the periostracal processes of the shell, the generatrix r as a function of distance from the origin along the axis of symmetry h was proven to be too complex to be described by a single continuous function, and as such was found numerically by dividing it into several segments. The functions describing these segments, as well as their corresponding domain and R^2 value are listed below:

$$r_1(h) = -5 \cdot 10^{-6}h^3 + 0.0022h^2 - 0.0706h + 34.547 \\ h \in (0;200) \quad R^2 = 0.9980$$

$$r_2(h) = 0.2928h + 14.689 \\ h \in (200;459) \quad R^2 = 0.9991$$

$$r_3(h) = -1.582 \cdot 10^{-7}h^3 - 4.040808 \cdot 10^{-4}h^2 + \\ 0.6317584237h - 40.5058825844 \\ h \in (459;725) \quad R^2 = 0.9839$$

$$r_4(h) = -9.0701134413047 \cdot 10^{-5}h^3 + \\ 0.207883829564922h^2 - 158.884236111089h \\ + 40632.8636822398 \\ h \in (725;868) \quad R^2 = 0.9964$$

The significant figures given above are important, as since the value of h grows to increasingly larger values in the latter equations, the precision to which the said equations are defined must also be increased. Thus, the general function of the generatrix $r(h)$ and its R^2 value are:

$$r(h) = \begin{cases} r_1(h) & h \in (0; 200) \\ r_2(h) & h \in (200; 459) \\ r_3(h) & h \in (459; 725) \\ r_4(h) & h \in (725; 868) \end{cases} \quad (4)$$

$$R^2 = 0.9937$$

Note that this is a general function describing any periostracal process, and that the domain of h is 0 to 868. This means that any such periostracal process is defined to be 868 units in length exactly. Inserting the above equation (4) into the formula for double arc length (1) returns the result for the perimeter length of periostracal process P in terms of u , which is the unit length along the axis of symmetry (i.e. the length of one h unit, or from equation (4): $\frac{1}{868}$ th of the length of the periostracal process).

$$P = \sum P_n = 1.8895 \cdot 10^3 u \quad (5)$$

Doing the same for surface area and volume with equations (2), (3) results in net surface area and volume of the periostracal process, S and V respectively:

$$S = \sum S_n = 6.4406 \cdot 10^5 u^2 \quad (6)$$

$$V = \sum V_n = 4.8695 \cdot 10^7 u^3 \quad (7)$$

Since not all of the periostracal processes are geometrically equal, as the majority of them are open on the underside (not clavate-like closed) and possess a “gap” in the otherwise perfect radial symmetry (for instance, Fig. 18), the model must be corrected. For perimeter length it was numerically determined that the quality had insignificant effect on the value. For surface area it can be accounted for by removing some angle θ , which corresponds to the missing circular sector. This can be done by



instead of multiplying by 2π in equation (2) using a factor of $2\pi - \theta$, which can be brought out of the summation sign and inserted instead in equation (6). The volume of the periostracal process however stays mostly the same in the case of a gap since they are comparatively small and the value of interest is that of the extended circular segment rather than the sector. Therefore correction for the volume of the periostracal process was only performed for cases where the value of θ was comparable to π radians, and ignored otherwise.

Since the length of the entire periostracal process is defined to be $868u$ (see equation 4), it is easy to equate this value to one actually measured, and hence get the value of u for the given case. Through inspection, these periostracal processes were counted and categorized according to their missing angle θ , length l , and amount present, N (Table 1).

Using this information, the values of u , u^2 and u^3 were calculated and inserted into equations (6) and (7), which were then multiplied by a factor

which accounted for the value of θ and the amount of periostracal processes N . The values were then summed up for the three categories to produce the net surface area S and volume V from the contribution of the periostracal processes:

$$S_{\text{process}} = 6.0298 \pm 1.2729 \text{ mm}^2 \quad (8)$$

$$V_{\text{process}} = 0.2010 \pm 0.0420 \text{ mm}^3 \quad (9)$$

For the case of contour length however, the only periostracal processes of interest are those that sit on the ultimate whorl, as that is the presumed area of contact with water. Through inspection it was noted that in this specimen the ultimate whorl contained 20 processes of "large" class. As such the net contour length contributed by the periostracal processes was obtained by multiplying equation (5) by a factor that accounted for the corresponding u -value and the 20 present processes, and was found to be

$$P_{\text{process}} = 3.2653 \pm 0.2177 \text{ mm} \quad (10)$$

Table 1. Size classes of periostracal processes in studied *Japonia saetigera* specimen.
Legends: l – length; N – quantity.

Size class of periostracal processes	N (pcs)	θ (rad)	Measured l (mm)	Mean l (mm)
Small (present on earlier whorls)	37	$\pi/6 \pm \pi/6$	$0.050\text{--}0.100 \pm 0.005$	0.075 ± 0.005
Midsize (on intermediate whorls)	38	$\pi/3 \pm \pi/6$	$0.100\text{--}0.300 \pm 0.005$	0.200 ± 0.005
Large (on pen- and ultimate whorls)	37	$\pi \pm \pi/6$	$0.400\text{--}0.700 \pm 0.005$	0.550 ± 0.005

Calculations for the smooth shell and results

The surface area and volume of the smooth shell without the periostracal processes were found analogously to those of periostracal processes. First, the length of periphery of shell's spire L was defined to be equal to $18068u$ and measured to be 24.3003 ± 2.51638 mm (resulting in a single u -value of $0.00134491 \pm 0.00014987$ mm). The relationship between the distance along the outer periphery of the shell (treating the shell apex as origin) L and the radius at that point R , and its R^2 value were then numerically determined to be:

$$R(L) = 1024.432514 - 967.7655137e^{(-0.00004819931 \cdot L)} \\ R^2 = 0.9975$$

Treating the volume of the spire and the shell surrounding its area as a Solid of revolution that has been "rolled-up" into a spiral permits the usage of equations (2) and (3) to again find the surface area and volume of the smooth shell, which were calculated to be equal to

and

$$S = 4.3101 \cdot 10^7 u^2 \quad (11)$$

$$V = 9.6035 \cdot 10^9 u^3 \quad (12)$$

respectively. Very much like the case with the periostracal processes, not all the surface should be considered, as due to the solid being "rolled-up" (Fig. 4), some of the surface is shared on the intersections between whorls, and due to the main interest pertaining to the visible surface of the shell (in view from above, as shown in Fig. 1); the area of the umbilical channel should not be counted either. Thus, through inspection (for instance, Fig. 2) it is estimated that the dorsal surface area of the shell is $28 \pm 3\%$ of the net surface area. Thus, multiplying equations (11) and (12) by this percentage and the calculated u -value results in dorsal surface area and volume of the smooth shell and were shown to be

$$S_{\text{shell}} = 21.8296 \pm 5.2125 \text{ mm}^2 \quad (13)$$

$$V_{\text{shell}} = 23.3634 \pm 7.8102 \text{ mm}^3 \quad (14)$$



For the case of perimeter however only the length of the ultimate whorl is of interest, as mentioned before. It was separately measured and found to be equal to

$$P_{shell} = 4.5337 \pm 0.4695 \text{ mm} \quad (15)$$

By summing the perimeter length, surface area and volume of the smooth shell (15), (13), (14) with the perimeter length, surface area and volume of the shell periostracal processes (10), (8), (9), the net perimeter length, dorsal surface area and volume can be calculated:

$$\begin{aligned} P_{net} &= 7.7990 \pm 0.5175 \text{ mm} \\ S_{net} &= 27.8594 \pm 0.3187 \text{ mm}^2 \\ V_{net} &= 23.5644 \pm 0.3941 \text{ mm}^3 \end{aligned}$$

The calculation results ($P_{process}/P_{net}$, $S_{process}/S_{net}$ and $V_{process}/V_{net}$) illustrate that the periostracal processes of the studied *Japonia saetigera* shell contribute to $41.87 \pm 9.41\%$ of the ultimate whorl perimeter length, $21.64 \pm 4.58\%$ of the net dorsal surface area of the shell and $0.85 \pm 0.18\%$ to the net volume of the shell.

Discussion

As it was demonstrated by Pfenninger et al. (2005), the presence of periostracal hairs increases adherence of terrestrial gastropod shells to wet substrates. Moreover, haired shells are proved to be an ancestral character state (Pfenninger et al. 2005). Suvorov (1999) pointed out that the only cause of the phenomenon of clean shells of litter-dwelling gastropods is due to the hydrophobic properties of their microsetose periostracum.

The terrain in Misool is complex at the study area (River Gam valley), with several steep subparallel limestone anticlines and deep ravines in-between. *Japonia saetigera* inhabits the wet floor of lowland rainforests in Misool, this species was found at low elevations at the base of limestone anticlines but not reported from the anticlines itself. Specimens are known to dwell in leaf litter. At the study area in the River Gam valley, it rains 1–3 times a day in February, March and April (second author, personal observation), but the soil remains constantly wet to very wet (Fig. 23) throughout the year with an annual rainfall about 2500 mm (Prentice & Hope 2007). Frequent showers ensure a continuous water flow from the anticlines down to the creeks and larger rivers. Thus, rainforest floor

gastropods are under a continuous risk of being flushed or sunk (Fig. 23).

We here hypothesise that the presence of periostracal processes in *Japonia saetigera* shell

1) is an adaptation to increase adherence of the shell to wet substrates (e.g. fallen leaves) due to shell area increment (Fig. 24);

2) may act as a floating adaptation in wet conditions: air bubbles can be "trapped" by spoon-shaped processes and can theoretically ensure floating (keeping the shell on the waters' surface);

3) the processes may serve to increase the perimeter of the shell allowing for more force to be applied before surface tension is broken. Under standard conditions, the ~42% increase in length translates to ~0.02 grams of additional mass that can be supported afloat.

The mechanism by which the increase in adherence presumably works is ensured by the water adhesion. The mechanism of adherence of air bubbles to a solid surface of a periostracal process is ensured by the capillary bridge-force (Hotta et al. 1974; Derjaguin et al. 1987; Myshkis et al. 1987). In its microhabitat (which is in fact a three-dimensional environment consisting of litter, soil, logs and fallen twigs), the conical shell of *Japonia saetigera* shell is nearly always in contact with two solid surfaces that are constantly wet – the first is the surface of the substrate to which snail's foot is attached (usually a fallen leaf), the second is another fallen leaf in the leaf litter, contacting the shell from above or from the sides, meaning that the snail is constantly covered from above and below (Fig. 24). Under these circumstances, the periostracal processes will adhere to both solid surfaces thanks to the conical shape of the shell. Indeed, these connections will be ensured by dorsal and ventral sides of processes depending on which side stays in a contact with a solid surface. Further experiments on living specimens involving appropriate equipment is planned to test the hypothesis.

By increasing the net dorsal surface area of the shell by over 20%, the periostracal processes can be considered to provide a significant increase in shell surface area (in terms of both hypotheses - to increase shell adherence or ensure shell floating). Contrary, contribution by the periostracal processes to the net volume of the shell (increase for <1%) considered not significant.

The periostracal processes, as discussed in the present paper for *Japonia saetigera*, appear in



similar or even more dramatic forms in some other terrestrial tropical cyclophorid molluscs from the Papuan Region, like in the enigmatic “*Mychopoma pennatum* van Benthem Jutting, 1958 (Figs 25–26), which is endemic to Misool Island and shares its the habitat with *J. saetigera* and is only known from the holotype stored in NMNL.

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Figures 1–3. *Japonia saetigera* (van Benthem Jutting, 1958). 1 – Studied and measured specimen from River Gam valley, Misool; 2–3 – Holotype (NMNL), periostracal processes absent (fallen), apertural (2) and umbilical (3) view.





4

2 mm

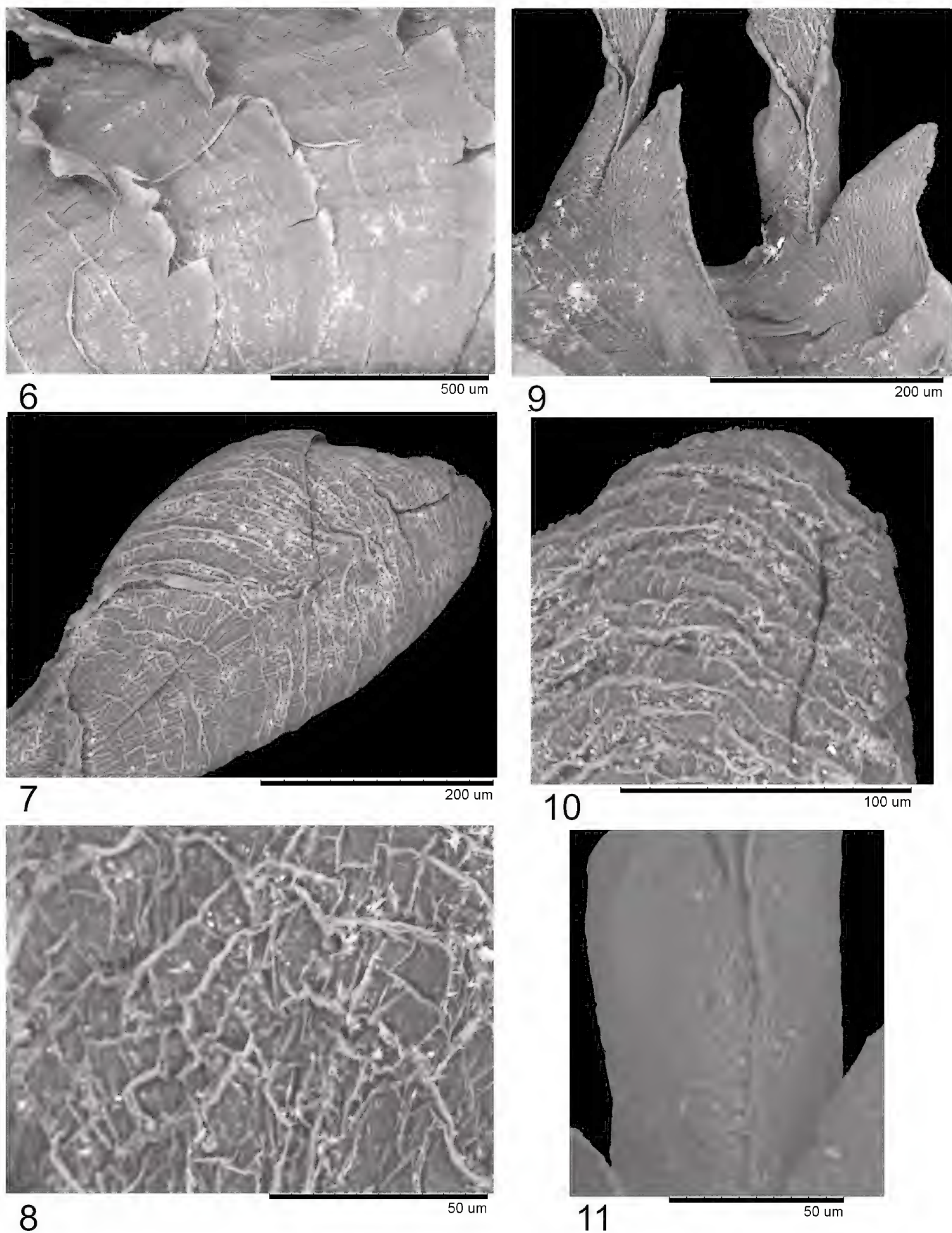


5

500 μm

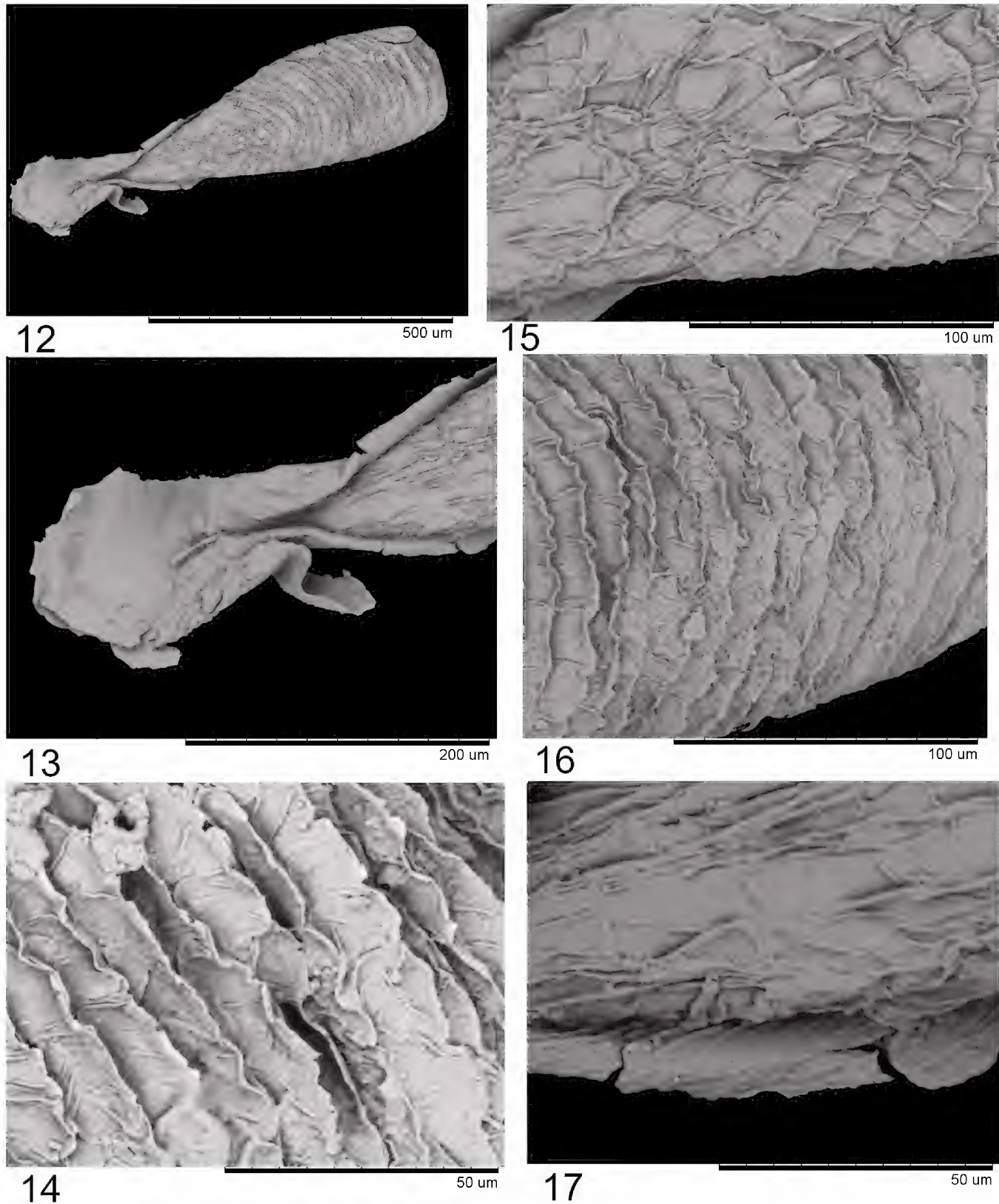
Figures 4–5. SEM micrographs of *Japonia saetigera* (van Benthem Jutting, 1958) specimen from River Gam valley, Misool. 4 – Apical view; 5 – Embryonic whorls (consider absence of periostracal processes).





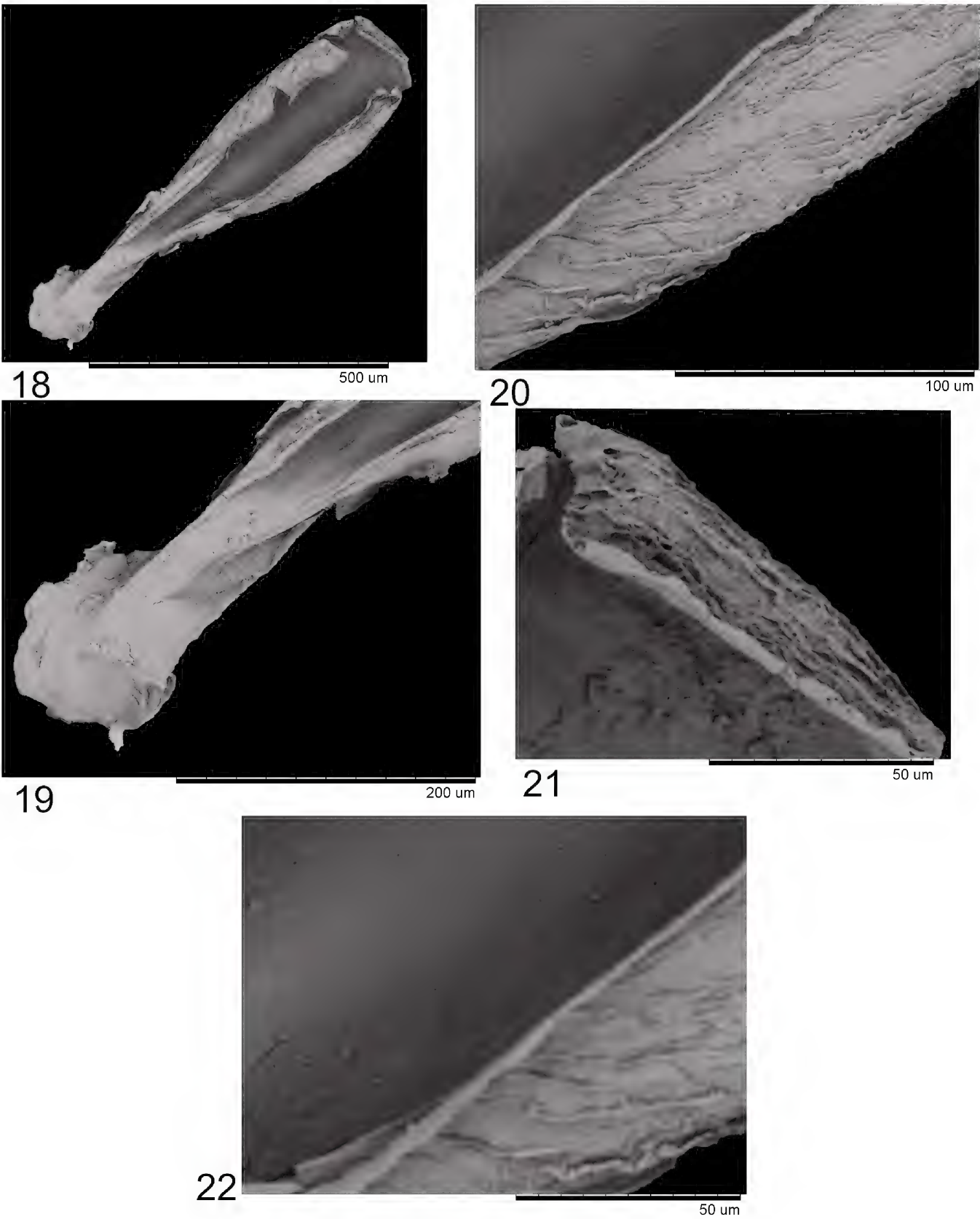
Figures 6–11. SEM micrographs of *Japonia saetigera* (van Benthem Jutting, 1958) specimen from River Gam valley, Misool. 6 – Lamellar periostracal extensions; 7 – Clavate (closed, empty inside) periostracal process, ventral view (consider presence of a median "suture"); 8 – Clavate periostracal process, dorsal view; 9 – Arising point of clavate periostracal processes on shell surface; 10 – Clavate periostracal process, ventral view (consider presence of a median "suture"); 11 – Basal (tubular) part of clavate periostracal process, ventral view (consider presence of a median "suture").





Figures 12–17. SEM micrographs of *Japonia saetigera* (van Benthem Jutting, 1958) specimen from River Gam valley, Misool. 12 – Amputated "open" periostracal process, dorsal view; 13 – Basal part of amputated "open" periostracal process; 14 – Median part of amputated "open" periostracal process, dorsal view; 15–17 – ditto; 17 – lateral margin of amputated "open" periostracal process, dorsal view.



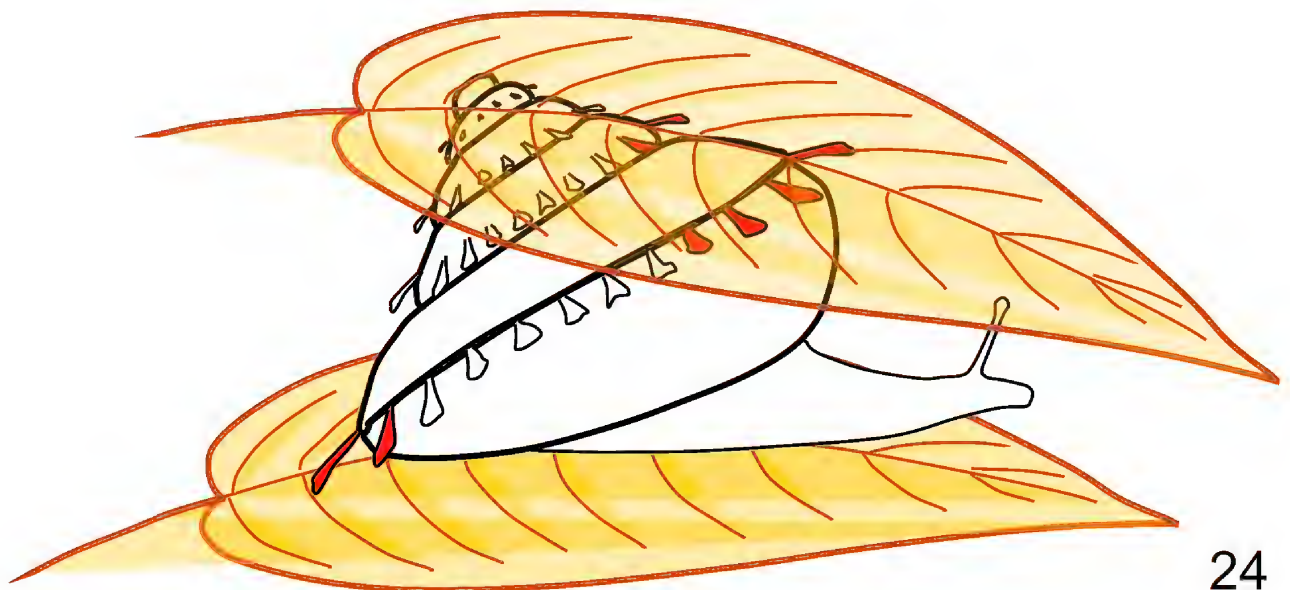


Figures 18–22. SEM micrographs of *Japonia saetigera* (van Benthem Jutting, 1958) specimen from River Gam valley, Misool. 18 – Amputated "open" periostracal process, ventral view; 19 – Basal part of amputated "open" periostracal process; 20–22 – Lateral margins (20–21) of amputated "open" periostracal process, ventral view; 22 – ditto but with visible median (nearly smooth) area.





23



24

Figures 23–24. 23 – Habitat of *Japonia saetigera* (van Benthem Jutting, 1958) in River Gam valley, Misool (consider constant water level and flow); 24 – Model of possible adhesive role of periostracal processes in *Japonia saetigera* (van Benthem Jutting, 1958) (those processes potentially in a contact with leaf litter marked red).





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Figures 25–26. "*Mychopoma*" *pennatum* van Benthem Jutting, 1958, holotype (NMNL), apical (25) and apertural (26) view (consider extreme feather-like periostracal processes on teleoconch, with possible adhesive or floating function). This species shares its habitat with *Japonia saetigerum* (van Benthem Jutting, 1958) [not to scale].

